

**REMARKS**

The claims pending in this Application are claims 1-31. Claims 1, 6, 11, 13, 14, 22, 24, and 25-28 have been amended. Claims 30 and 31 are newly added. Initially, claims 13 and 24, which were objected to as being dependent upon a rejected base claim, have been amended in independent form to include all the limitations of their respective base claims. In light of these amendments, claims 13 and 24 are believed to be allowable over the prior art of record. Claims 11 and 22 have been amended to more clearly recite the feature where the boron is evaporated at the claimed pressure. Newly added claims 30 and 31 relate to methods of forming an oxygen-based superconductor. Support for these claimed features is found in paragraphs [0060] – [0062] of the specification as well as in original claim 27.

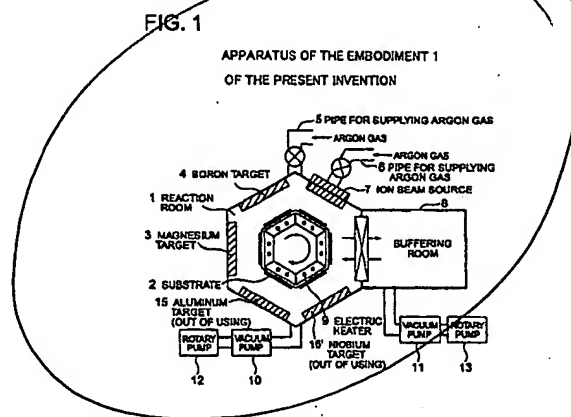
ch. 30 + 31

Paragraph [0056] of the specification has been amended to correct the units of temperature for the  $\text{MgB}_2$  film created on the polycrystalline alumina substrate and the flexible stainless steel tape substrate. As seen in Figs. 5 and 6, the correct units for  $T_c$  is Kelvin.

In the Office Action dated October 11, 2006, claims 6 and 25 were rejected under § 35 U.S.C. § 102(a/e) as being anticipated by U.S. Patent No. 6,514,557 (Finnemore et al.). These same claims were rejected as being anticipated under § 102(e) as being anticipated by or, in the alternative, being obvious (under § 103(a)) over U.S. Patent No. 6,835,696 (Saito et al.). Applicants have amended claims 6 and 25 such that they are not drafted in product-by-process form. Instead, claims 6 and 25 recited the claimed feature wherein the reaction zone contains gaseous magnesium at a partial pressure of about 10 mTorr. Support for this amendment can be found, for instance, in paragraph [0037], lines 16-19. In

light of the amendments made to claims 6 and 25, the rejection of the claims is believed to be mooted.

Claims 1-5, 7-12, and 26-29 stand rejected as being unpatentable under 35 U.S.C. § 103(a) as being unpatentable over Saito et al. Applicants traverse this rejection. Saito et al. relates to a method of forming a superconducting film ( $\text{MgB}_2$ ) which is made from a carousel-type sputtering device. See FIG. 1 and Col. 4, lines 5-8. The device includes magnesium and boron targets that are contained *in a common chamber*. Substrates on which the films are formed are positioned about a rotating carousel. FIG. 1 of Saito et al. is reproduced below to shown the single, common chamber.



Ionized argon gas bombards the targets causing atoms/ions of boron and magnesium to be ejected. Col. 3, lines 35-39. The Saito et al. device permits low temperature formation of films (substrate at 250 °C to 400 °C).

Initially, claim 1 has been amended to recite a method of forming  $\text{MgB}_2$  films on a substrate in which boron deposition on the surface of a substrate takes place in a *depressurized zone*. In addition, claim 1 has been amended to recite the feature where the reaction zone containing the pressurized gaseous magnesium is separate from and substantially sealed from the aforementioned depressurized zone. Similar amendments

have been made with respect to independent claims 14 and 26. Claim 26 also includes the claimed feature where the deposition zone is depressurized – having a pressure less than  $10^{-5}$  Torr and the reaction zone being substantially free of oxygen.

Saito et al. does not employ a separate reaction chamber or zone for the magnesium and boron. Rather, as best seen in FIG. 1, a common chamber is used in the simultaneous sputtering of magnesium and boron. For at least this reason, Saito et al. fails to disclose or suggest a depressurized zone where boron deposition takes place. Similarly, the reactor of Saito et al. does not include a reaction zone that contains pressurized gaseous magnesium in a separate region that is substantially sealed from the boron deposition zone. In contrast, Applicants' method of separating boron deposition (in a depressurized region) from a separate, substantially sealed reaction zone containing pressurized, gaseous magnesium provides numerous benefits. One significant benefit of Applicants' method is that, in the reaction zone (containing, for instance, the pressurized magnesium), there is little or no chance of the magnesium being contaminated with elements or species (e.g., oxygen) that may be present in the deposition zone. The sealing arrangement is created by the tight tolerances of the device and by the fact that any magnesium vapor that escapes condenses, getters, and promotes the sealing relationship. See e.g., specification ¶ [0037] (lines 13-16); ¶ [0055]. Reduced contamination promotes high quality  $MgB_2$  films to be formed.

Yet another benefit from the claimed separate, yet sealed reaction zone is that the method creates the relatively high pressures needed for successful thin film growth of materials containing high vapor pressure species like magnesium. Other techniques like that disclosed in Saito et al. (which discloses a reaction pressure of around 2 mTorr, see

Col. 4, line 35), cannot create elevated pressures of magnesium because it is not localized and the evaporated magnesium goes everywhere in the system. This leads to two problems: (1) the magnesium pressure is too low for optimal growth at the desired temperature, and (2) oxygen or some other contaminant in the system may find its way into the newly-formed thin film since the reaction does not take place in a separate cell or zone. Without the separate, sealed reaction zone containing the pressurized magnesium gas (or other volatile species), the required high pressures needed for magnesium cannot be obtained. Moreover, because Saito et al. uses sputtering, a high-pressure carrier gas (such as Ar or a pressure of around 2 mTorr) is needed.

The differences between the two methods can also be seen in the quality of  $\text{MgB}_2$  films that are created. The Saito et al. device and method produces films having relatively low  $T_c$  temperatures (e.g., below  $\sim 30$  K). The  $\text{MgB}_2$  films created using Applicants' method are of extremely high quality, having high  $T_c$  values (e.g., around 38-39 K). See e.g., Figs. 5 and 6. In addition, the residual resistance ratio (RRR) in the films produced in the Saito et al. device is on the order of 1 while the RRR values of the films produced by Applicant's device and method is much higher – on the order of  $\sim 5$ . See Fig. 5 (dividing resistivity at 300 K by the resistivity at 40 K). In light of the amendments made herein, Applicants submit that the claimed invention is not anticipated or rendered obvious in light of the teachings of Saito et al.

Claims 26-29 stand rejected as being anticipated under § 102(b) by U.S. Patent Application Publication No. 2001/0036214A1 (Bozovic et al.). Initially, claim 26 has been amended to recite the claimed features mentioned above, namely, that the deposition zone is a depressurized region having a pressure less than  $10^{-5}$  Torr and the reaction zone being

substantially free of oxygen. Further, the reaction zone that contains a pressurized gaseous phase of an element forming the superconducting film is substantially sealed from the depressurized deposition zone.

Bozovic et al. discloses a method and device that uses pulsed laser deposition (PLD) to volatilize a target containing a superconducting precursor element. The substrate on which the HTS thin film is formed is cycled between exposure to the PLD plume and exposure to a high pressure of oxygen or volatile metallic elements such as Hg, Tl, Pb, Bi, K, and Rb. Because the device of Bozovic et al. is PLD-based, it uses a relatively high pressure – much higher than that used in the current claimed process. For instance, Bozovic et al. specifically discloses that its process is distinct and different from thermal co-evaporation techniques. See Col. 3, ¶ [0046] (“The key difference is that they use thermal co-evaporation and much lower pressure in both the deposition stage (typically  $10^{-5}$  Torr), and the oxidation stage (typically  $10^{-2}$  -  $10^{-1}$  Torr). In contrast, we [Bozovic et al.] are using PLD, and much (1,000-100,000 times) higher pressure.”). The low pressure used in Applicants’ method is important because at higher pressures (like those used in Bozovic et al.), there is a greater possibility of contamination with other species. Contamination will reduce the overall quality of the thin film, including adversely affecting  $T_c$ . Moreover, the high pressures used in the PLD process would not be compatible with the thermal deposition processes envisioned in the current process (e.g., e-beam evaporation).

Still another difference between the claimed method of claims 26-29 and the method disclosed in Bozovic et al. is that, in the claimed method, the reaction zone is substantially free of oxygen. In contrast, Bozovic et al. teaches the use of oxygen (either molecular oxygen, ozone, atomic oxygen, or  $\text{NO}_2$ ) to form, for instance,  $\text{TlBaCaCuO}$  and

HgBaCaCuO. Oxygen is either present in the PLD chamber or in the pressurized chamber. For example, in the formation of  $\text{MgB}_2$ , no oxygen should be present because its presence would lead to contamination and thus low quality films. To the extent that Applicants' method contemplates use of oxygen in the film formation process, this is done in a separate, sealed chamber like the one used in the reaction zone (see e.g., new claims 30 and 31).

In summary, Bozovic et al. fails to disclose or suggest at least the features of the (1) low pressure, (2) or a substantially oxygen free environment. Moreover, one skilled in the art would not look to Bozovic et al. because its own disclosure specifically teaches away from thermal co-evaporation methods like that employed by Applicants. Bozovic et al.'s PLD-based solution along with the use of oxygen within the larger reaction environment is directly contrary to the method and device of the present claims. For this reason, the claims patentably distinguish over Bozovic et al.

In addition, claim 28 has been amended to recite the feature where there are a plurality of deposition zones and a plurality of reaction zones. For example, paragraphs [0064] through [0066] (and the accompanying Fig. 18) describe an embodiment that includes multiple deposition zones and multiple reaction zones. As seen in Fig. 18, zones B and D might be deposition zones while zones A and C may be reaction zones. See specification, ¶ [0064], lines 9-14. While a conveyor-based system is employed in Fig. 18, other configurations may also be used. Id., lines 14-16. Regardless of the ultimate configuration, however, Bozovic et al. lacks any teaching or suggestion of multiple deposition and reaction zones in the sealed configuration as recited in claim 28.

In light of the amendments and remarks made herein, the Application should be in condition for allowance. If there are any questions concerning this submission, please contact the undersigned at (949) 677-7758.

Respectfully submitted,  
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Dated: January 11, 2007

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